

**CLAIMS**

1. An apparatus, comprising:

a polyphase machine having a plurality of sets of polyphase windings, each of the respective windings of a first of the sets of polyphase windings being inductively linked to one of each of the respective windings of the remaining sets of polyphase windings;

a polyphase inverter operable to receive power from the windings of the first set and to produce a polyphase output; and

a plurality of single-phase inverters, each operable to receive power from the windings of a respective one of the remaining sets and to produce a single-phase output,

wherein each of the respective phases of the polyphase output may be coupled in series or parallel with one of the respective single-phase outputs to produce an aggregate polyphase output.

2. The apparatus of claim 1, wherein:

the polyphase machine includes four sets of three-phase windings;

the polyphase inverter is a first inverter operable to produce a three-phase output;

the remaining inverters are second, third, and fourth inverters, each operable to produce a single-phase output; and

each of the respective phases of the three-phase output may be coupled in series or in parallel with one of the respective single-phase outputs to produce an aggregate three-phase output.

3. The apparatus of claim 1, wherein:

the first set of polyphase windings are sized to deliver about one half of an output power of the aggregate polyphase output; and

each of the remaining sets of polyphase windings are sized to deliver about  $1/(2 \times (N - 1))$  of the output power of the aggregate polyphase output, where N is the number of sets of polyphase windings.

4. The apparatus of claim 1, wherein:

the polyphase inverter is sized to deliver about one half of an output power of the aggregate polyphase output; and

each of the single-phase inverters are sized to deliver about  $1/(2 \times (N - 1))$  of the output power of the aggregate polyphase output, where N is the number of sets of polyphase windings.

5. The apparatus of claim 1, wherein the inverters are synchronized with one another such that each of the respective single-phase outputs are substantially in phase with one of the respective phases of the polyphase output.

6. The apparatus of claim 1, wherein each of the inverters includes a polyphase rectifier operable to receive power from the windings of a respective one of the sets of polyphase windings, and to produce a respective source of DC power.

7. The apparatus of claim 6, wherein:

the polyphase inverter includes: a full multiphase bridge circuit having a plurality of legs coupled across an associated one of the sources of DC power, each leg

including a pair of series coupled switching elements forming an intermediate node; and a plurality of low pass filters, each being operatively coupled to a respective one of the intermediate nodes and producing a respective output phase of the polyphase output; and

each of the single-phase inverters includes: a half bridge circuit having a single leg coupled across an associated one of the sources of DC power, the leg including a pair of series coupled switching elements forming an intermediate node; and a low pass filter operatively coupled to the intermediate node and producing an associated one of the single-phase outputs.

8. The apparatus of claim 7, further comprising a control circuit operable to produce a driver signal for each of the switching elements of the inverters.

9. The apparatus of claim 8, wherein respective pairs of the driver signals that are used to drive the switching elements of the respective legs of the polyphase inverter are also used to drive the switching elements of the respective pair of switching elements of the leg of each single-phase inverter.

10. The apparatus of claim 9, wherein the sources of DC power of the polyphase inverter and of the single-phase inverters are regulated with respect to one another.

11. The apparatus of claim 8, wherein the control circuit is operable to produce driver signals for the inverters, such that (i) respective voltage magnitudes of the phases of the polyphase output are about one half of

respective voltage magnitudes of the phases of the aggregate polyphase output; and (ii) respective voltage magnitudes of the single-phase outputs are about one half of the respective voltage magnitudes of the phases of the aggregate polyphase output, when the respective phases of the polyphase output are coupled in series with the respective single-phase outputs to produce the aggregate polyphase output.

12. The apparatus of claim 11, wherein the control circuit is further operable to produce driver signals for the inverters, such that (i) respective current magnitudes of the phases of the polyphase output are about equal to respective current magnitudes of the phases of the aggregate polyphase output; and (ii) respective current magnitudes of the single-phase outputs are about equal to the respective current magnitudes of the phases of the aggregate polyphase output.

13. The apparatus of claim 8, wherein the control circuit is operable to produce driver signals for the inverters, such that (i) respective voltage magnitudes of the phases of the polyphase output are about equal to respective voltage magnitudes of the phases of the aggregate polyphase output; and (ii) respective voltage magnitudes of the single-phase outputs are about equal to the respective voltage magnitudes of the phases of the aggregate polyphase output, when the respective phases of the polyphase output are coupled in parallel with the respective single-phase outputs to produce the aggregate polyphase output.

14. The apparatus of claim 13, wherein the control circuit is further operable to produce driver signals for

the inverters, such that (i) respective current magnitudes of the phases of the polyphase output are about one half of respective current magnitudes of the phases of the aggregate polyphase output; and (ii) respective current magnitudes of the single-phase outputs are about one half of the respective current magnitudes of the phases of the aggregate polyphase output.

15. The apparatus of claim 7, wherein the polyphase rectifier of the polyphase inverter includes an intermediate polyphase inverter that is operable to receive power from the windings of the first set of polyphase windings, and to produce and voltage regulate the source of DC power.

16. The apparatus of claim 15, wherein the intermediate polyphase inverter includes a full multiphase bridge circuit having a plurality of legs coupled across the source of DC power, each leg including a pair of series coupled switching elements forming an intermediate node, each being operatively coupled to a respective one of the windings of the first set of polyphase windings.

17. The apparatus of claim 16, further comprising a control circuit operable to produce a driver signal for each of the switching elements of the intermediate polyphase inverter.

18. The apparatus of claim 17, wherein the control circuit is operable to produce the driver signals such that the intermediate polyphase inverter boosts voltage received from the first set of polyphase windings to produce a boosted voltage at the source of DC power.

19. The apparatus of claim 18, wherein the control circuit is further operable to cause the intermediate polyphase inverter to boost respective voltages received from the remaining sets of polyphase windings to produce respective boosted voltages at the other sources of DC power of the single-phase inverters, by way of the inductive link between the first set of polyphase windings and one of each of the respective windings of the remaining sets of polyphase windings.

20. The apparatus of claim 19, wherein each of the respective windings of the first set of polyphase windings is wound in a multifilar configuration with one of each of the respective windings of the remaining sets of polyphase windings to increase the inductive link therebetween.

21. The apparatus of claim 20, wherein each of the respective sets of polyphase windings are in a WYE configuration.

22. The apparatus of claim 17, wherein the control circuit is operable to produce the driver signals such that the intermediate polyphase inverter drives the polyphase machine as a motor.

23. An apparatus, comprising:

means for receiving power from a first set of polyphase windings of a polyphase machine and converting the power into a polyphase output;

means for receiving power from remaining sets of polyphase windings of the a polyphase machine and inverting the power into respective single-phase outputs, wherein respective windings of the first set of polyphase windings

are inductively linked to one of each of respective windings of the remaining sets of polyphase windings; and

means for producing an aggregate polyphase output by coupling each of the respective phases of the polyphase output in series or in parallel with one of the respective single-phase outputs.

24. The apparatus of claim 23, further comprising means for producing a respective source of DC power for each inverter from the received power from the windings of a respective one of the sets of polyphase windings of the polyphase machine.

25. The apparatus of claim 23, further comprising:

means for controlling the polyphase inverter such that respective voltage magnitudes of the phases of the polyphase output are about one half of respective voltage magnitudes of the phases of the aggregate polyphase output; and

means for controlling the single-phase inverters such that respective voltage magnitudes of the single-phase outputs are about one half of the respective voltage magnitudes of the phases of the aggregate polyphase output,

when the respective phases of the polyphase output are coupled in series with the respective single-phase outputs to produce the aggregate polyphase output.

26. The apparatus of claim 25, further comprising:

means for controlling the polyphase inverter such that respective current magnitudes of the phases of the polyphase output are about equal to respective current magnitudes of the phases of the aggregate polyphase output; and

means for controlling the single-phase inverters such that respective current magnitudes of the single-phase

outputs are about equal to the respective current magnitudes of the phases of the aggregate polyphase output.

27. The apparatus of claim 23, further comprising:

means for controlling the polyphase inverter such that respective voltage magnitudes of the phases of the polyphase output are about equal to respective voltage magnitudes of the phases of the aggregate polyphase output; and

means for controlling the single-phase inverters such that respective voltage magnitudes of the single-phase outputs are about equal to the respective voltage magnitudes of the phases of the aggregate polyphase output,

when the respective phases of the polyphase output are coupled in parallel with the respective single-phase outputs to produce the aggregate polyphase output.

28. The apparatus of claim 27, further comprising:

means for controlling the polyphase inverter such that respective current magnitudes of the phases of the polyphase output are about one half of respective current magnitudes of the phases of the aggregate polyphase output; and

means for controlling the single-phase inverters such that respective current magnitudes of the single-phase outputs are about one half of the respective current magnitudes of the phases of the aggregate polyphase output.

29. The apparatus of claim 23, further comprising:

means for producing a respective source of DC power for each single-phase inverter from the received power from the windings of a respective one of the sets of polyphase windings of the polyphase machine;

means for producing a source of DC power for the polyphase inverter that is operable to receive power from

the windings of the first set of polyphase windings, and to boost the voltage received from the first set of polyphase windings to produce a boosted voltage at the source of DC power.

30. The apparatus of claim 29, wherein the means for producing the source of DC power for the polyphase inverter is for boosting respective voltages received from the remaining sets of polyphase windings to produce respective boosted voltages at the other sources of DC power of the single-phase inverter, by way of the inductive link between the first set of polyphase windings and one of each of the respective windings of the remaining sets of polyphase windings.

31. The apparatus of claim 29, wherein the means for producing the source of DC power for the polyphase inverter is for driving the polyphase machine as a motor.

32. A method, comprising:

receiving power in a polyphase inverter from a first set of polyphase windings of a polyphase machine and converting the power into a polyphase output;

receiving power in a plurality of single-phase inverters from remaining sets of polyphase windings of the polyphase machine and converting the power into respective single-phase outputs, wherein respective windings of the first set of polyphase windings are inductively linked to one of each of respective windings of the remaining sets of polyphase windings; and

producing an aggregate polyphase output by coupling each of the respective phases of the polyphase output in

series or in parallel with one of the respective single-phase outputs.

33. The method of claim 32, wherein the polyphase machine includes four sets of three-phase windings, the polyphase inverter produces a three-phase output, and three single-phase inverters produce respective single-phase outputs, and the step of producing the aggregate polyphase output includes coupling each of the respective phases of the three-phase output in series or in parallel with one of the respective single-phase outputs.

34. The method of claim 32, further comprising:  
sizing the first set of polyphase windings to deliver about one half of an output power of the aggregate polyphase output; and

sizing each of the remaining sets of polyphase windings to deliver about one sixth of the output power of the aggregate polyphase output.

35. The method of claim 32, further comprising:  
sizing the first set of polyphase windings to deliver about one half of an output power of the aggregate polyphase output; and

sizing each of the remaining sets of polyphase windings to deliver about  $1/(2 \times (N - 1))$  of the output power of the aggregate polyphase output, where N is the number of sets of polyphase windings.

36. The method of claim 32, further comprising:  
sizing the polyphase inverter to deliver about one half of an output power of the aggregate polyphase output; and

sizing each of the single-phase inverters to deliver about one sixth of the output power of the aggregate polyphase output.

37. The method of claim 32, further comprising:

sizing the polyphase inverter to deliver about one half of an output power of the aggregate polyphase output; and

sizing each of the single-phase inverters to deliver about  $1/(2 \times (N - 1))$  of the output power of the aggregate polyphase output, where N is the number of sets of polyphase windings.

38. The method of claim 32, further comprising synchronizing the inverters with one another such that each of the respective single-phase outputs are substantially in phase with one of the respective phases of the polyphase output.

39. The method of claim 32, further comprising producing a respective source of DC power for each inverter from the received power from the windings of a respective one of the sets of polyphase windings of the polyphase machine.

40. The method of claim 39, wherein the step of producing the respective source of DC power is performed using a respective polyphase rectifier.

41. The method of claim 32, further comprising:

controlling the polyphase inverter such that respective voltage magnitudes of the phases of the polyphase output are about one half of respective voltage magnitudes of the phases of the aggregate polyphase output; and

controlling the single-phase inverters such that respective voltage magnitudes of the single-phase outputs are about one half of the respective voltage magnitudes of the phases of the aggregate polyphase output,

when the respective phases of the polyphase output are coupled in series with the respective single-phase outputs to produce the aggregate polyphase output.

42. The method of claim 41, further comprising:

controlling the polyphase inverter such that respective current magnitudes of the phases of the polyphase output are about equal to respective current magnitudes of the phases of the aggregate polyphase output; and

controlling the single-phase inverters such that respective current magnitudes of the single-phase outputs are about equal to the respective current magnitudes of the phases of the aggregate polyphase output.

43. The method of claim 32, further comprising:

controlling the polyphase inverter such that respective voltage magnitudes of the phases of the polyphase output are about equal to respective voltage magnitudes of the phases of the aggregate polyphase output; and

controlling the single-phase inverters such that respective voltage magnitudes of the single-phase outputs are about equal to the respective voltage magnitudes of the phases of the aggregate polyphase output,

when the respective phases of the polyphase output are coupled in parallel with the respective single-phase outputs to produce the aggregate polyphase output.

44. The method of claim 43, further comprising:

controlling the polyphase inverter such that respective current magnitudes of the phases of the polyphase output are about one half of respective current magnitudes of the phases of the aggregate polyphase output; and

controlling the single-phase inverters such that respective current magnitudes of the single-phase outputs are about one half of the respective current magnitudes of the phases of the aggregate polyphase output.

45. The method of claim 32, wherein:

the polyphase inverter includes: a full multiphase bridge circuit having a plurality of legs coupled across an associated one of the sources of DC power, each leg including a pair of series coupled switching elements forming an intermediate node; and a plurality of low pass filters, each being operatively coupled to a respective one of the intermediate nodes and producing a respective output phase of the polyphase output; and

each of the single-phase inverters includes: a half bridge circuit having a single leg coupled across an associated one of the sources of DC power, the leg including a pair of series coupled switching elements forming an intermediate node; and a low pass filter operatively coupled to the intermediate node and producing an associated one of the single-phase outputs.

46. The method of claim 45, further comprising producing a driver signal for each of the switching elements of the inverters.

47. The method of claim 46, using respective pairs of the driver signals that are used to drive the switching elements of the respective legs of the polyphase inverter to

drive the switching elements of the respective pair of switching elements of the leg of each single-phase inverter.

48. The method of claim 47, further comprising maintaining the sources of DC power of the polyphase inverter and of the single-phase inverters regulated with respect to one another.

49. The method of claim 32, further comprising: producing a respective source of DC power for each single-phase inverter from the received power from the windings of a respective one of the sets of polyphase windings of the polyphase machine;

producing a source of DC power for the polyphase inverter using an intermediate polyphase inverter that is operable to receive power from the windings of the first set of polyphase windings, and to produce and voltage regulate the source of DC power.

50. The method of claim 49, wherein the intermediate polyphase inverter includes: a full multiphase bridge circuit having a plurality of legs coupled across the source of DC power, each leg including a pair of series coupled switching elements forming an intermediate node, each being operatively coupled to a respective one of the windings of the first set of polyphase windings; and a control circuit operable to produce a driver signal for each of the switching elements of the intermediate polyphase inverter.

51. The method of claim 49, further comprising controlling the intermediate polyphase inverter to boost the voltage received from the first set of polyphase windings to produce a boosted voltage at the source of DC power.

52. The method of claim 51, further comprising controlling the intermediate polyphase inverter to boost respective voltages received from the remaining sets of polyphase windings to produce respective boosted voltages at the other sources of DC power of the single-phase inverter, by way of the inductive link between the first set of polyphase windings and one of each of the respective windings of the remaining sets of polyphase windings.

53. The method of claim 52, wherein each of the respective windings of the first set of polyphase windings is wound in a multifilar configuration with one of each of the respective windings of the remaining sets of polyphase windings to increase the inductive link therebetween.

54. The method of claim 53, wherein each of the respective sets of polyphase windings are in a WYE configuration.

55. The method of claim 49, further comprising controlling the intermediate polyphase inverter such that it drives the polyphase machine as a motor.